Photo Guide
for Estimating Fuel Loading and Fire Behavior in Mixed-Oak Forests of the Mid-Atlantic Region

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General Technical Report NRS-45

Abstract

A field guide of 45 pairs of photographs depicting ericaceous shrub, leaf litter, and logging slash fuel types of eastern oak forests and observed fire behavior of these fuel types during prescribed burning. The guide contains instructions on how to use the photo guide to choose appropriate fuel models for prescribed fire planning.

The Author

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Cover photos: Mountain laurel and logging slash fuel types and their observed fire behavior during prescribed burning. All photos by Patrick Brose, U.S. Forest Service.

Photo Guide for Estimating Fuel Loading and Fire Behavior in Mixed-Oak Forests of the Mid-Atlantic Region

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Introduction

Throughout the eastern United States, prescribed fire is a new practice to help regenerate mixed-oak (*Quercus* spp.) forests (Yaussy 2000, Dickinson 2006, Hutchinson 2009). In this capacity, prescribed fire functions as a site preparation tool in mature stands, helping establish new oak seedlings from acorns, or as a release agent in shelterwoods and clearcuts, freeing existing oak reproduction from competing vegetation (Brose and others 2006, Brose and others 2008). Because burning in mixed-oak forests is a new concept, many resource managers lack experience in planning and conducting prescribed fires in this forest type. This lack of experience is especially pronounced in terms of estimating fuel loadings in the different fuel types commonly found in mixed-oak forests and predicting their expected fire behavior for given weather conditions. Photo guides can help resource managers overcome unfamiliarity with oak forest fuels and their fire behavior tendencies and aid in the preparation of sound prescribed fire plans.

This photo guide is a sequence of photographs and accompanying data that depict a variety of common fuel conditions. The photos provide a quick and easy means to quantify wildland fuels for a particular forest type or plant community. Photo guides are common in the southern and western states (Wade and others 1993, Scholl and Waldrop 1999, Ottmar and others 2000), but few exist for eastern oak forests. Wilcox and others (1982) published a small, single-photo guide for the northern hardwood and oak-hickory types in Pennsylvania. It focused on woody fuels in undisturbed mature stands. A similar style guide of pine-dominated forests included a few photos of fire-disturbed stands (Lynch and Horton 1983). Sanders and Van Lear (1988) published a paired photo (preburn and postburn) guide of mixed pine-oak clearcuts in the southern Appalachian region of South Carolina. More recently, photo series of the Great Lakes and Northeast regions contained some photographs and fuels data for mixed-oak forests (Ottmar and Vihnanek 1999, Wright and others 2006). Unfortunately, none of these photo guides contained many photos or much fuels data either from oak stands containing ericaceous shrubs [blueberry (*Vaccinium* spp.), huckleberry (*Gayluscia* spp.), mountain laurel (*Kalmia latifolia*)] or oak stands that had been partially or completely harvested.

This photo guide will assist forest managers in planning prescribed fires in mixed-oak stands by simplifying fuels inventories; identifying appropriate standard fuel models for ericaceous shrub, leaf litter, and logging slash fuels; predicting probable minimum and maximum fire behavior for these fuel types; and providing sufficiently detailed fuels data for the development of custom fuel models, when needed.

Methods

This photo guide was developed from 11 mixed-oak stands on federal and state land in New Jersey and Pennsylvania that received a single prescribe burn between 2002 and 2008. These stands were dominated by the five upland oak species [black (*Q. velutina*), chestnut (*Q. montana*), northern red (*Q. rubra*), scarlet (*Q. coccinea*), and white (*Q. alba*)], and also contained associated species such as American beech (*Fagus grandifolia*), black birch (*Betula lenta*), black cherry (*Prunus serotina*), eastern hemlock (*Tsuga canadensis*), pitch pine *(Pinus rigida*), red maple (*Acer rubrum*), white pine (*Pinus strobus*), and yellow-poplar (*Liriodendron tulipifera*), depending on site quality. Generally, these stands were partially stocked (basal areas ranged from 70 to 110 ft^2/ac) due to past disturbances or recent timber harvesting.

Prior to burning, each stand was scouted for uniform areas (fuel beds) of ericaceous shrubs, leaf litter, and logging slash that exceeded 40 ft by 40 ft in size and were unchanging in aspect and slope. In the center of each fuel bed, a 30 ft by 30 ft plot was established and inventoried for fuel loading, height, and cover. Woody fuels were inventoried by the time-lag size classes described by Fosberg (1970) along fifteen 15-ft transects that uniformly transversed the plot. Woody fuel counts were converted to tons/ac loadings using the standard equations (Brown 1974). Fuel height was measured to the nearest 0.1 ft at the midpoint of each transect. Litter and shrub loadings were determined by collecting these materials from a 1.2 yd^2 quadrat at the end of every third transect, drying them at 75 °C to a constant weight, and weighing them to the nearest 0.1 ounce. Fuel cover was determined by standing in the center of each plot and visually estimating the proportion of the plot covered by leaf litter and shrubs.

A permanent photopoint was established approximately 30 ft from each fuels plot on the downhill side. From this position, a preburn photo was taken of each fuels plot from a height of 6 ft with a tripod-mounted Canon EOS Elan camera using a 35-mm lens. Generally, photos were taken several days before each burn and in overcast conditions.

During the prescribed fires, weather conditions (air temperature, relative humidity, wind direction, wind speed, and cloud cover) were measured every 15 minutes with a belt-weather kit (Forestry Suppliers, Jackson, MS). Moisture content for 10-hour fuels was determined immediately before each burn with a wood moisture meter (Forestry Suppliers, Jackson, MS). Also during the prescribed burns, the flaming front was photographed or videotaped as it passed through or near the plots. Flame length was estimated from these photographs by using the diameter of overstory trees to estimate flame length to the nearest foot. Rate-of-spread was calculated by placing a thermocouple and data logger (Onset Computer Corp., Bourne, MA) in the corners and center of each plot. These devices measured the time (seconds) and temperature (degrees Fahrenheit) during the prescribed burn and this data allowed calculation of rate-of-spread in ft/min as the flaming front passed through the plot. Generally, three to five flame-length and rate-of-spread calculations were made for each plot.

The fuels data and weather readings were used in BehavePlus 3.0 (Andrews and others 2005) to identify which of the fuel models described by Anderson (1982) most closely predicted the average fire behavior recorded during the prescribed burns. Also, two additional fuel models were selected based on their outputs reflecting the minimum and maximum fire behavior measured during the prescribed burns.

How to use this photo guide

This guide consists of 45 pairs of photos and accompanying data. They are arranged by fuel type (5 leaf litter, 20 ericaceous shrub, 20 logging slash) and in order of increasing fuel loading within each fuel type. In each pair, the upper photo shows the fuels plot before burning and the lower photo shows fire behavior in or near the fuels plot. On the facing page are three tables containing site information, fuels characteristics, and weather/fire behavior data.

To use this photo guide, scout a proposed burn unit in a systematic manner. As you encounter areas of the three fuel types, look through the guide and select a photo that closely resembles the fuels you observe. The fire photo shows the type of fire behavior you can expect given the data provided in the three tables. The fuels table also contains the three fuel models that produced BEHAVE-generated fire behavior predictions matching the average, minimum, and maximum flame lengths and rates of spread recorded during the burns. If a more specific fire behavior prediction is needed, the site information and fuels data can be used in BEHAVE to produce a custom fuel model. Sometimes, no photo perfectly depicts the field condition. In those cases, select a pair of photos that appear to bracket the observed fuels.

Remember that a photo guide is an elementary aid for estimating fuel characteristics and predicting fire behavior. Many additional factors influence fire behavior so users should be advised that this guide depicts only a few of the possible situations. Also, this guide is designed for low-intensity fall and moderate- to high-intensity spring prescribed fires. Burns conducted at other times of the year and under different topography and weather conditions will likely produce different fire behavior from that depicted in this guide.

Photos/data are arranged by fuel type (5 leaf litter, 20 ericaceous shrub, 20 logging slash) and in order of increasing fuel loading within each fuel type.

The upper photo shows the fuels plot before burning and the lower photo shows fire behavior in or near the fuels plot.

Acknowledgments

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References

Anderson, H.E. 1982. **Aids to determining fuel models for estimating fire behavior.** Gen. Tech. Rep. INT-122. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 22 p.

Andrews, P.L.; Bevins, C.D.; Seli, R.C. 2005. **BehavePlus fire modeling system version 3.0: User's guide.** Gen. Tech. Rep. RMRS-106. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 130 p.

Brose, P.H.; Schuler, T.M.; Ward, J.S. 2006. **Responses of oak and other hardwood regeneration to prescribed fire: what we know as of 2005.** In: Dickinson, M.B., ed. Fire in eastern oak forests: delivering science to land managers. Gen. Tech. Rep. NRS-P-1. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 123-135.

Brose, P.H.; Gottschalk, K.W.; Horsley, S.B.; Knopp, P.D.; Kochenderfer, J.N.; McGuinness, B.J.; Miller, G.W.; Ristau, T.E.; Stoleson, S.H.; Stout, S.L. 2008. **Prescribing regeneration treatments for mixed-oak forests of the mid-Atlantic region.** Gen. Tech. Rep. NRS-33. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 100 p.

Brown, J.K. 1974. **Handbook for inventorying downed woody material.** Gen. Tech. Rep. INT-16. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 24 p.

Dickinson, M.B., ed. 2006. **Fire in eastern oak forests: delivering science to land managers.** Gen. Tech. Rep. NRS-P-1. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 303 p.

Fosberg, M.A. 1970. **Drying rates of wood below fiber saturation.** Forest Science. 16: 57-63.

Hutchinson, Todd F., ed. 2009. **Proceedings of the 3rd fire in eastern oak forests conference;** 2008 May 20-22; Carbondale, IL. Gen. Tech. Rep. NRS-P-46. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 154 p.

Lynch, C.M.; Horton, L.J. 1983. **Photo series for quantifying forest residues in loblolly pine, eastern white pine, pitch pine, and Virginia pine.** For. Rep. NA-FR-25. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry. 69 p.

Ottmar, R.D.; Vihnanek, R.E. 1999. **Stereo photo series for quantifying natural fuels. Volume V: midwest red and white pine, northern tallgrass prairie, and mixed oak types in the Central and Lake States.** Publication Management System 834. Boise, ID: National Wildfire Coordinating Group, National Interagency Fire Center. 99 p.

Ottmar, R.D.; Vihnanek, R.E.; Wright, C.S. 2000. **Stereo photo series for quantifying natural fuels. Volume III: Lodgepole pine, quaking aspen, and gambel oak types in the Rocky Mountains.** Publication Management System 832. Boise, ID: National Wildfire Coordinating Group, National Interagency Fire Center. 85 p.

Sanders, B.M.; Van Lear, D.H. 1988. **Photos for estimating residue loadings before and after burning in Southern Appalachian mixed pine-hardwood clearcuts.** Gen. Tech. Rep. SE-49. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 21 p.

Scholl, E.R.; Waldrop, T.A. 1988. **Photos for estimating fuel loadings before and after prescribed burning in the upper coastal plain of the southeast.** Gen. Tech. Rep. SRS-26. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 25 p.

Wade, D.D.; Forbus, J.K.; Saveland, J.M. 1993. **Photo series for estimating post-hurricane residues and fire behavior in southern pine.** Gen. Tech. Rep. SE-82. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 19 p.

Wilcox, F.; McCarty, J.; Bungard, B. 1982. **Photo series for quantifying forest residues in the northern hardwood type, oak-hickory type.** For. Rep. NA-FR-22. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry. 43 p.

Wright, C.S.; Ottmar, R.D.; Vihnanek, R.E. 2006. **Stereo photo series for quantifying natural fuels, Volume VIII: hardwood, pitch pine, and red spruce/balsam fir types in the northeastern United States.** Publication Management System 840. Boise, ID: National Wildfire Coordinating Group, National Interagency Fire Center. 91 p.

Yaussy, D.A., comp. 2000. **Fire, people, and the central hardwood landscape.** Gen. Tech. Rep. NE-274. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 129 p.

Leaf Litter

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Leaf Litter 1

Site Information

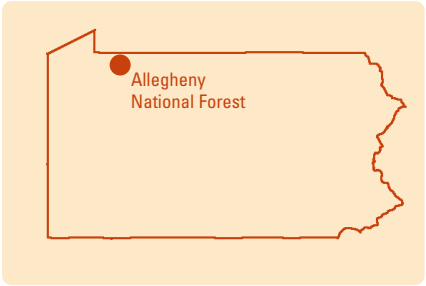
Location	Allegheny National Forest, Warren County, Pennsylvania
Overstory metrics	118 trees/acre; basal area 87 feet/acre; stocking 53 percent
Overstory composition	Red maple, northern red oak, chestnut oak, white oak
Aspect/elevation/slope	Northeast; 1,900 feet; 7 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.6 tons/acre	Litter cover	100 percent
1-hour woody	0.8 tons/acre	Ave. fuel height	0.2 feet
10-hour woody	1.3 tons/acre	Ave. fuel moisture	11 percent
100-hour woody	0.9 tons/acre	Optimal fuel model	9
Total fuels	6.6 tons/acre	Min/max Fuel Models	8, 2

Weather and Fire Behavior Data

Air temperature	79 °F	Burn date/time	09 May 2005, 1600
Relative humidity	22 percent	Firing device	Drip torch
Wind direction	Southwest	Firing pattern	Strip-head fire
Wind speed	2 to 4 miles/hour	Flame lengths	0.5 to 2 feet
Cloud cover	0 percent	Rates of spread	1 to 4 feet/minute
Days since rain, amt.	2, trace		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Leaf Litter 2

Site Information

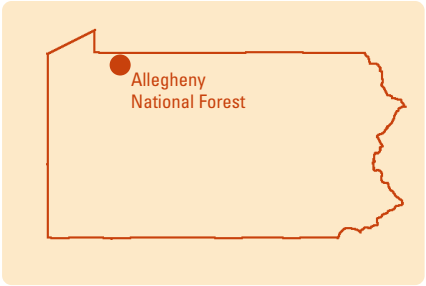
Location	Allegheny National Forest, Warren County, Pennsylvania
Overstory metrics	118 trees/acre; basal area 87 feet/acre; stocking 53 percent
Overstory composition	Red maple, northern red oak, chestnut oak, white oak
Aspect/elevation/slope	Northeast; 1,900 feet; 7 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.5 tons/acre	Litter cover	100 percent
1-hour woody	0.8 tons/acre	Ave. fuel height	0.2 feet
10-hour woody	1.7 tons/acre	Ave. fuel moisture	11 percent
100-hour woody	1.3 tons/acre	Optimal fuel model	9
Total fuels	7.3 tons/acre	Min/max fuel model	8, 2

Weather and Fire Behavior Data

Air temperature	79 °F	Burn date/time	09 May 2005, 1600
Relative humidity	22 percent	Firing device	Drip torch
Wind direction	Southwest	Firing pattern	Strip-head fire
Wind speed	2 to 4 miles/hour	Flame lengths	0.5 to 2 feet
Cloud cover	0 percent	Rates of spread	1 to 4 feet/minute
Days since rain, amt.	2, trace		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Leaf Litter 3

Site Information

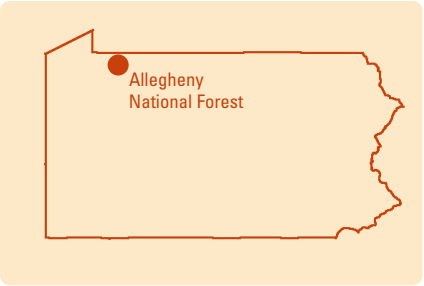
Location	Allegheny National Forest, Warren County, Pennsylvania
Overstory metrics	118 trees/acre; basal area 87 feet/acre; stocking 53 percent
Overstory composition	Red maple, northern red oak, chestnut oak, white oak
Aspect/elevation/slope	Northeast; 1,900 feet; 7 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.4 tons/acre	Litter cover	100 percent
1-hour woody	1.2 tons/acre	Ave. fuel height	0.3 feet
10-hour woody	1.4 tons/acre	Ave. fuel moisture	11 percent
100-hour woody	2.4 tons/acre	Optimal fuel model	9
Total fuels	8.4 tons/acre	Min/max fuel model	8, 2

Weather and Fire Behavior Data

Air temperature	79 °F	Burn date/time	09 May 2005, 1600
Relative humidity	23 percent	Firing device	Drip torch
Wind direction	Southwest	Firing pattern	Strip-head fire
Wind speed	2 to 4 miles/hour	Flame lengths	0.5 to 2 feet
Cloud cover	0 percent	Rates of spread	1 to 5 feet/minute
Days since rain, amt.	2, trace		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Leaf Litter 4

Site Information

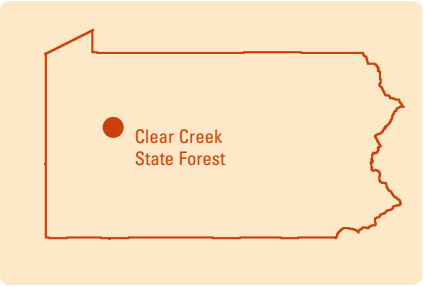
Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	153 trees/acre; basal area 112 feet/acre; stocking 73 percent
Overstory composition	Northern red oak, red maple, black cherry, yellow-poplar
Aspect/elevation/slope	East; 1,650 feet; 15 percent
Stand history	Shelterwood preparatory cut (whole-tree harvest) in 2000

Fuel Characteristics

Leaf litter	3.5 tons/acre	Litter cover	100 percent
1-hour woody	1.7 tons/acre	Ave. fuel height	0.2 feet
10-hour woody	1.8 tons/acre	Ave. fuel moisture	5 percent
100-hour woody	2.1 tons/acre	Optimal fuel model	9
Total fuels	9.1 tons/acre	Min/max fuel model	8, 2

Weather and Fire Behavior Data

Air temperature	83 °F	Burn date/time	10 May 2005, 1000
Relative humidity	17 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	3 to 5 miles/hour	Flame lengths	1 to 4 feet
Cloud cover	0 percent	Rates of spread	2 to 6 feet/minute
Days since rain, amt.	8, 0.1 inch		



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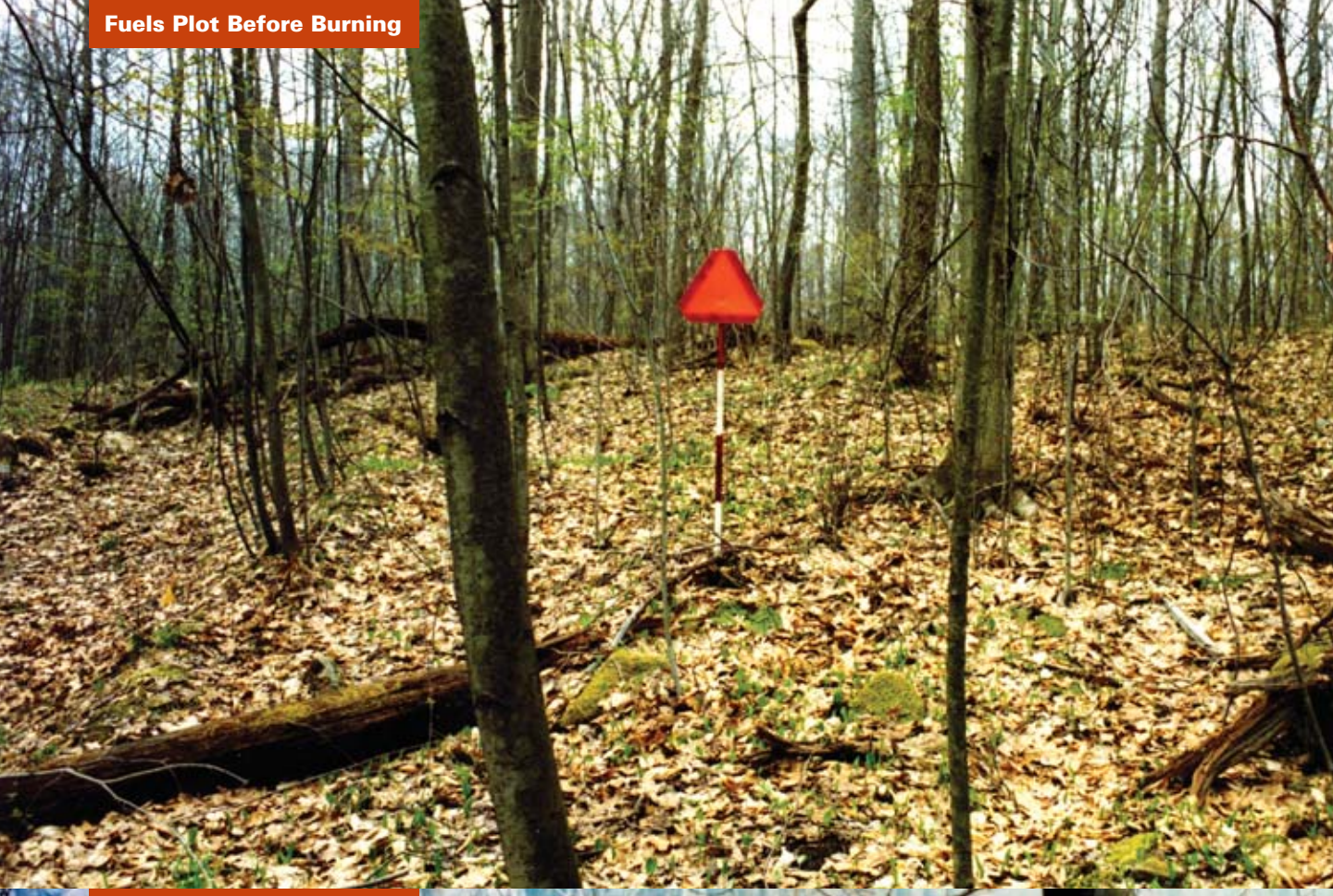


Fuels Plot Before Burning

Fuels Plot Fire Behavior

Leaf Litter 5

Site Information

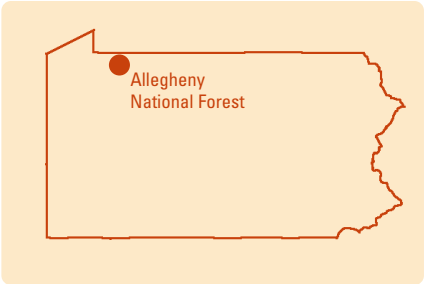
Location	Allegheny National Forest, Warren County, Pennsylvania
Overstory metrics	77 trees/acre; basal area 83 feet/acre; stocking 47 percent
Overstory composition	Northern red oak, red maple, chestnut oak, white oak
Aspect/elevation/slope	Northwest; 1,950 feet; 5 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.5 tons/acre	Litter cover	100 percent
1-hour woody	1.8 tons/acre	Ave. fuel height	0.3 feet
10-hour woody	2.3 tons/acre	Ave. fuel moisture	12 percent
100-hour woody	2.7 tons/acre	Optimal fuel model	9
Total fuels	10.3 tons/acre	Min/max fuel model	8, 2

Weather and Fire Behavior Data

Air temperature	66 °F	Burn date/time	06 May 2005, 1430
Relative humidity	40 percent	Firing device	Drip torch
Wind direction	Southwest	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	30 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	6, 0.1 inch		



Photos by Patrick Brose, U.S. Forest Service

Ericaceous Shrub

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 1

Site Information

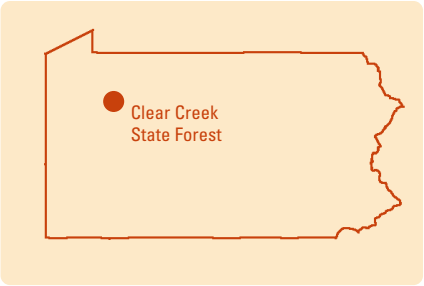
Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	252 trees/acre; basal area 138 feet/acre; stocking 96 percent
Overstory composition	Northern red oak, red maple, black cherry, yellow-poplar
Understory composition	Blueberry, huckleberry
Aspect/elevation/slope	East; 1,750 feet; 2 percent
Stand history	No management for several decades

Fuel Characteristics

Leaf litter	3.0 tons/acre	Litter cover	100 percent
1-hour woody	4.2 tons/acre	Shrub cover	75 percent
10-hour woody	1.5 tons/acre	Ave. fuel height	0.5 feet
100-hour woody	0.8 tons/acre	Ave. fuel moisture	7 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	9.5 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	83 °F	Burn date/time	10 May 2005, 1000
Relative humidity	17 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	3 to 5 miles/hour	Flame lengths	1 to 4 feet
Cloud cover	0 percent	Rates of spread	2 to 6 feet/minute
Days since rain, amt.	8, 0.1 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 2

Site Information

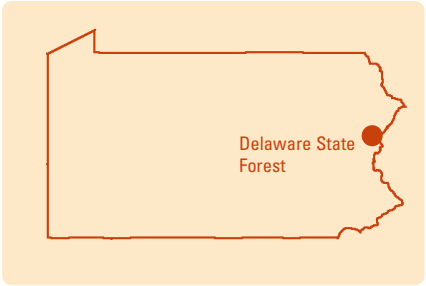
Location	Delaware State Forest, Pike County, Pennsylvania
Overstory metrics	132 trees/acre; basal area 96 feet/acre; stocking 76 percent
Overstory composition	Chestnut oak, scarlet oak, white oak, red maple
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	East; 1,325 feet; 11 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.5 tons/acre	Litter cover	100 percent
1-hour woody	3.6 tons/acre	Shrub cover	75 percent
10-hour woody	3.0 tons/acre	Ave. fuel height	0.7 feet
100-hour woody	2.3 tons/acre	Ave. fuel moisture	14 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	12.4 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	57 °F	Burn date/time	09 Nov 2005, 1300
Relative humidity	31 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 3 feet
Cloud cover	0 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	4, 0.3 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 3

Site Information

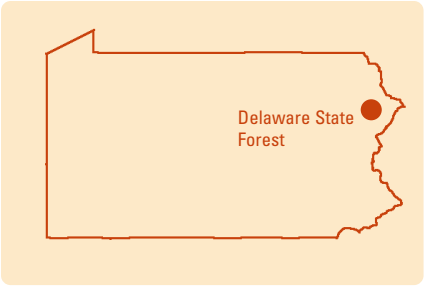
Location	Delaware State Forest, Pike County, Pennsylvania
Overstory metrics	132 trees/acre; basal area 96 feet/acre; stocking 76 percent
Overstory composition	Chestnut oak, scarlet oak, white oak, red maple
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	East; 1,325 feet; 11 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	2.8 tons/acre	Litter cover	95 percent
1-hour woody	3.2 tons/acre	Shrub cover	70 percent
10-hour woody	3.5 tons/acre	Ave. fuel height	0.8 feet
100-hour woody	4.2 tons/acre	Ave. fuel moisture	14 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	13.7 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	57°F	Burn date/time	09 Nov 2005, 1300
Relative humidity	31 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	0 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	4, 0.3 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 4

Site Information

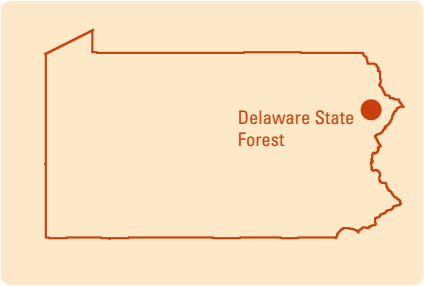
Location	Delaware State Forest, Pike County, Pennsylvania
Overstory metrics	132 trees/acre; basal area 96 feet/acre; stocking 76 percent
Overstory composition	Chestnut oak, scarlet oak, white oak, red maple
Understory composition	Blueberry, buckleberry, mountain laurel
Aspect/elevation/slope	East; 1,325 feet; 11 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

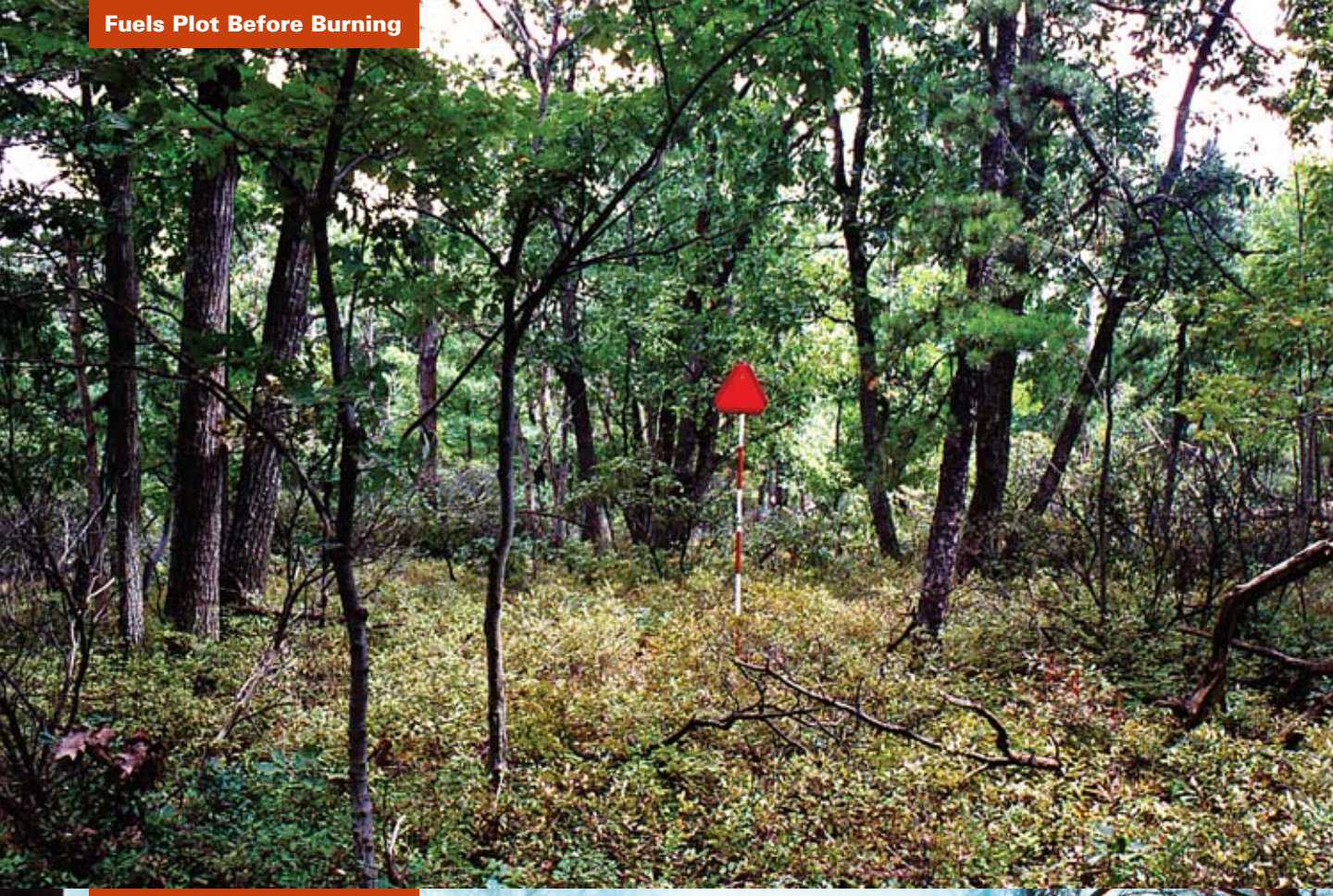
Leaf litter	3.2 tons/acre	Litter cover	100 percent
1-hour woody	3.7 tons/acre	Shrub cover	85 percent
10-hour woody	3.0 tons/acre	Ave. fuel height	1.1 feet
100-hour woody	4.6 tons/acre	Ave. fuel moisture	14 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	14.5 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	57 °F	Burn date/time	09 Nov 2005, 1300
Relative humidity	31 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	0 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	4, 0.3 inch		



Photos by Patrick Brose, U.S. Forest Service



Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 5

Site Information

Location	Delaware Water Gap NRA, Sussex County, New Jersey
Overstory metrics	114 trees/acre; basal area 79 feet/acre; stocking 62 percent
Overstory composition	Chestnut oak, scarlet oak, red maple, pitch pine
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	West; 1,270 feet; 8 percent
Stand history	Gypsy moth mortality in late 1980s and mid 1990s

Fuel Characteristics

Leaf litter	3.5 tons/acre	Litter cover	100 percent
1-hour woody	3.2 tons/acre	Shrub cover	90 percent
10-hour woody	2.8 tons/acre	Ave. fuel height	1.3 feet
100-hour woody	5.6 tons/acre	Ave. fuel moisture	17 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	15.1 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	54 °F	Burn date/time	16 Nov 2004, 1400
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	Northwest	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	10 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	3, 0.25 inch		

Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 6

Site Information

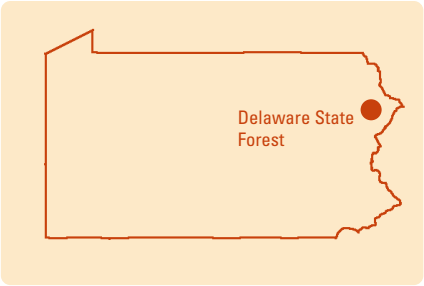
Location	Delaware State Forest, Pike County, Pennsylvania
Overstory metrics	132 trees/acre; basal area 96 feet/acre; stocking 76 percent
Overstory composition	Chestnut oak, scarlet oak, white oak, red maple
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	East; 1,325 feet; 11 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.7 tons/acre	Litter cover	100 percent
1-hour woody	4.0 tons/acre	Shrub cover	70 percent
10-hour woody	3.4 tons/acre	Ave. fuel height	0.6 feet
100-hour woody	5.0 tons/acre	Ave. fuel moisture	14 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	16.1 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	57 °F	Burn date/time	09 Nov 2005, 1300
Relative humidity	31 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	0 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	4, 0.3 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 7

Site Information

Location	Delaware Water Gap NRA, Sussex County, New Jersey
Overstory metrics	114 trees/acre; basal area 79 feet/acre; stocking 62 percent
Overstory composition	Chestnut oak, scarlet oak, red maple, pitch pine
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	West; 1,270 feet; 8 percent
Stand history	Gypsy moth mortality in late 1980s and mid 1990s

Fuel Characteristics

Leaf litter	3.3 tons/acre	Litter cover	95 percent
1-hour woody	3.7 tons/acre	Shrub cover	80 percent
10-hour woody	2.5 tons/acre	Ave. fuel height	0.8 feet
100-hour woody	7.2 tons/acre	Ave. fuel moisture	17 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	16.7 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	54 °F	Burn date/time	16 Nov 2004, 1400
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	Northwest	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	10 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	3, 0.25 inch		

Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 8

Site Information

Location	Delaware Water Gap NRA, Sussex County, New Jersey
Overstory metrics	114 trees/acre; basal area 79 feet/acre; stocking 62 percent
Overstory composition	Chestnut oak, scarlet oak, red maple, pitch pine
Understory composition	Blueberry, huckleberry, Mountain laurel
Aspect/elevation/slope	West; 1,270 feet; 8 percent
Stand history	Gypsy moth mortality in late 1980s and mid 1990s

Fuel Characteristics

Leaf litter	3.4 tons/acre	Litter cover	100 percent
1-hour woody	3.6 tons/acre	Shrub cover	90 percent
10-hour woody	4.9 tons/acre	Ave. fuel height	1.7 feet
100-hour woody	3.9 tons/acre	Ave. fuel moisture	17 percent
1,000-hour woody	2.6 tons/acre	Optimal fuel model	6
Total fuels	18.4 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	54 °F	Burn date/time	16 Nov 2004, 1400
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	Northwest	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	10 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	3, 0.25 inch		

Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 9

Site Information

Location	Delaware Water Gap NRA, Sussex County, New Jersey
Overstory metrics	114 trees/acre; basal area 79 feet/acre; stocking 62 percent
Overstory composition	Chestnut oak, scarlet oak, red maple, pitch pine
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	West; 1,270 feet; 8 percent
Stand history	Gypsy moth mortality in late 1980s and mid 1990s

Fuel Characteristics

Leaf litter	3.1 tons/acre	Litter cover	100 percent
1-hour woody	3.8 tons/acre	Shrub cover	90 percent
10-hour woody	3.2 tons/acre	Ave. fuel height	1.8 feet
100-hour woody	9.2 tons/acre	Ave. fuel moisture	17 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	19.3 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	54 °F	Burn date/time	16 Nov 2004, 1400
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	Northwest	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	10 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	3, 0.25 inch		

Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 10

Site Information

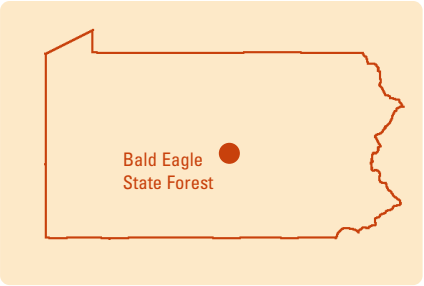
Location	Bald Eagle State Forest, Centre County, Pennsylvania
Overstory metrics	109 trees/acre; basal area 85 feet/acre; stocking 63 percent
Overstory composition	Chestnut oak, scarlet oak, white oak, red maple
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	North; 1,850 feet; 17 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.3 tons/acre	Litter cover	100 percent
1-hour woody	4.7 tons/acre	Shrub cover	85 percent
10-hour woody	3.4 tons/acre	Ave. fuel height	1.2 feet
100-hour woody	8.1 tons/acre	Ave. fuel moisture	10 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	19.5 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	71 °F	Burn date/time	21 May 2002, 1200
Relative humidity	23 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 4 feet
Cloud cover	0 percent	Rates of spread	3 to 7 feet/minute
Days since rain, amt.	7, 0.25 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 11

Site Information

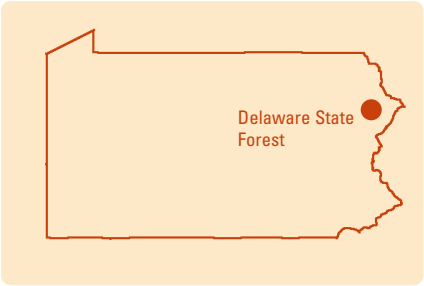
Location	Delaware State Forest, Pike County, Pennsylvania
Overstory metrics	132 trees/acre; basal area 96 feet/acre; stocking 76 percent
Overstory composition	Chestnut oak, scarlet oak, white oak, red maple
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	East; 1,325 feet; 11 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.1 tons/acre	Litter cover	100 percent
1-hour woody	2.5 tons/acre	Shrub cover	75 percent
10-hour woody	3.6 tons/acre	Ave. fuel height	1.6 feet
100-hour woody	7.0 tons/acre	Ave. fuel moisture	14 percent
1,000-hour woody	3.8 tons/acre	Optimal fuel model	6
Total fuels	20.0 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	57 °F	Burn date/time	09 Nov 2005, 1300
Relative humidity	31 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 4 feet
Cloud cover	0 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	4, 0.3 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 12

Site Information

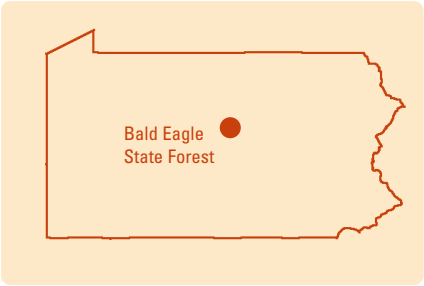
Location	Bald Eagle State Forest, Centre County, Pennsylvania
Overstory metrics	109 trees/acre; basal area 85 feet/acre; stocking 63 percent
Overstory composition	Chestnut oak, scarlet oak, white oak, red maple
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	North; 1,850 feet; 17 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

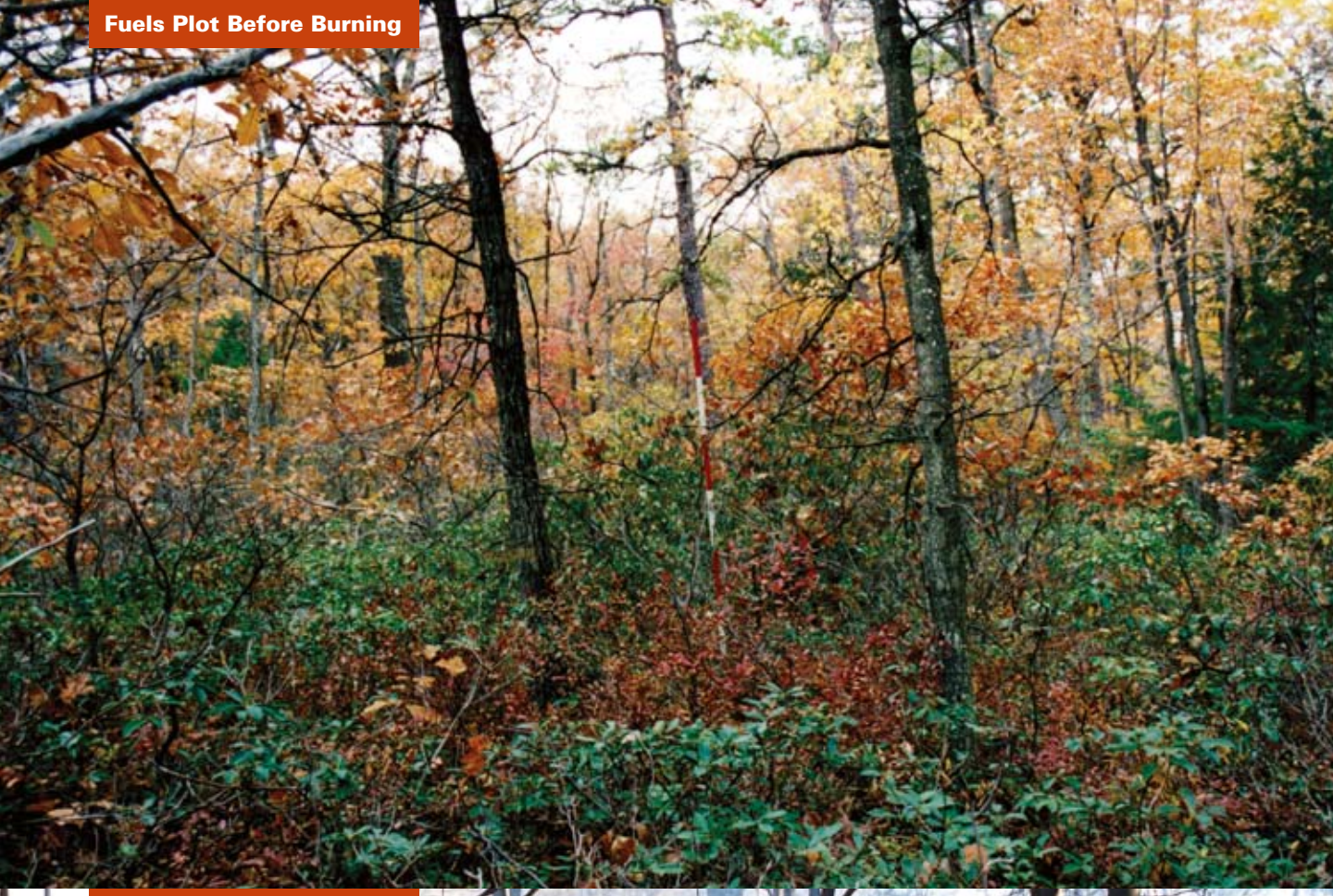
Leaf litter	3.8 tons/acre	Litter cover	100 percent
1-hour woody	4.7 tons/acre	Shrub cover	90 percent
10-hour woody	5.1 tons/acre	Ave. fuel height	1.3 feet
100-hour woody	7.6 tons/acre	Ave. fuel moisture	10 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	21.2 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	71 °F	Burn date/time	21 May 2002, 1200
Relative humidity	23 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 4 feet
Cloud cover	0 percent	Rates of spread	3 to 7 feet/minute
Days since rain, amt.	7, 0.25 inch		



Photos by Patrick Brose, U.S. Forest Service



Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 13

Site Information

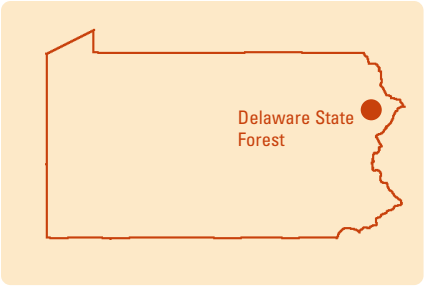
Location	Delaware State Forest, Pike County, Pennsylvania
Overstory metrics	132 trees/acre; basal area 96 feet/acre; stocking 76 percent
Overstory composition	Chestnut oak, scarlet oak, white oak, red maple
Understory composition	Blueberry, huckleberry, mountain laurel
Aspect/elevation/slope	East; 1,325 feet; 11 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

Fuel Characteristics

Leaf litter	3.6 tons/acre	Litter cover	100 percent
1-hour woody	4.6 tons/acre	Shrub cover	90 percent
10-hour woody	3.7 tons/acre	Ave. fuel height	1.6 feet
100-hour woody	9.4 tons/acre	Ave. fuel moisture	14 percent
1,000-hour woody	0.0 tons/acre	Optimal fuel model	6
Total fuels	21.3 tons/acre	Min/max fuel model	9, 10

Weather and Fire Behavior Data

Air temperature	57 °F	Burn date/time	09 Nov 2005, 1300
Relative humidity	31 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 4 feet
Cloud cover	0 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	4, 0.3 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 14

Site Information

Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	123 trees/acre; basal area 108 feet/acre; stocking 78 percent
Overstory composition	Chestnut oak, red maple, northern red oak, white oak
Understory composition	Mountain laurel
Aspect/elevation/slope	South; 1,825 feet; 16 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

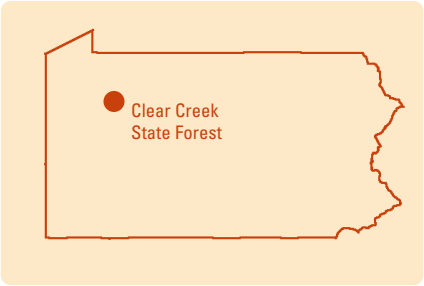
Fuel Characteristics

Leaf litter	3.6 tons/acre	Litter cover	100 percent
1-hour woody	3.6 tons/acre	Shrub cover	85 percent
10-hour woody	4.1 tons/acre	Ave. fuel height	2.8 feet
100-hour woody	6.8 tons/acre	Ave. fuel moisture	15 percent
1,000-hour woody	5.5 tons/acre	Optimal fuel model	5*
Total fuels	23.6 tons/acre	Min/max fuel model	10*, 4*

Weather and Fire Behavior Data

Air temperature	64 °F	Burn date/time	01 May 2003, 1200
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	5 to 10 feet
Cloud cover	50 percent	Rates of spread	5 to 10 feet/minute
Days since rain, amt.	3, 0.25 inch		

* None of the 13 standard fuel models adequately characterize mountain laurel. Developing a custom fuel model may be the most appropriate choice for this fuel type.



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 15

Site Information

Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	123 trees/acre; basal area 108 feet/acre; stocking 78 percent
Overstory composition	Chestnut oak, red maple, northern red oak, white oak
Understory composition	Mountain laurel
Aspect/elevation/slope	South; 1,825 feet; 16 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

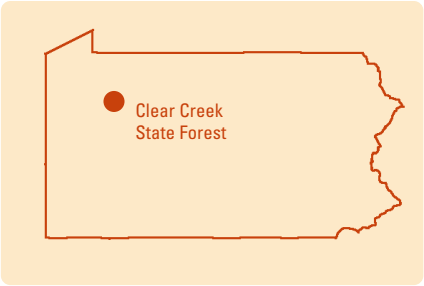
Fuel Characteristics

Leaf litter	3.8 tons/acre	Litter cover	100 percent
1-hour woody	4.1 tons/acre	Shrub cover	75 percent
10-hour woody	4.0 tons/acre	Ave. fuel height	2.2 feet
100-hour woody	6.5 tons/acre	Ave. fuel moisture	15 percent
1,000-hour woody	6.2 tons/acre	Optimal fuel model	5*
Total fuels	24.6 tons/acre	Min/max fuel model	10*, 4*

Weather and Fire Behavior Data

Air temperature	64 °F	Burn date/time	01 May 2003, 1200
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	5 to 10 feet
Cloud cover	50 percent	Rates of spread	5 to 10 feet/minute
Days since rain, amt.	3, 0.25 inch		

* None of the 13 standard fuel models adequately characterize mountain laurel. Developing a custom fuel model may be the most appropriate choice for this fuel type.



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 16

Site Information

Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	103 trees/acre; basal area 95 feet/acre; stocking 69 percent
Overstory composition	Chestnut oak, red maple, northern red oak, white oak
Understory composition	Mountain laurel
Aspect/elevation/slope	South; 1,800 feet; 5 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

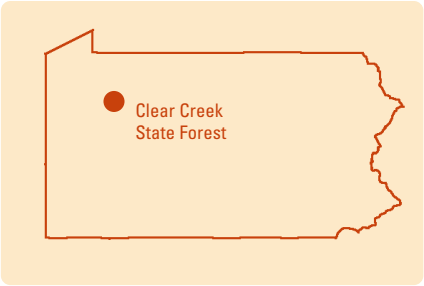
Fuel Characteristics

Leaf litter	3.5 tons/acre	Litter cover	100 percent
1-hour woody	4.8 tons/acre	Shrub cover	95 percent
10-hour woody	4.8 tons/acre	Ave. fuel height	3.2 feet
100-hour woody	5.9 tons/acre	Ave. fuel moisture	15 percent
1,000-hour woody	5.7 tons/acre	Optimal fuel model	5*
Total fuels	24.7 tons/acre	Min/max fuel model	10*, 4*

Weather and Fire Behavior Data

Air temperature	64 °F	Burn date/time	01 May 2003, 1200
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	5 to 10 feet
Cloud cover	50 percent	Rates of spread	5 to 10 feet/minute
Days since rain, amt.	3, 0.25 inch		

* None of the 13 standard fuel models adequately characterize mountain laurel. Developing a custom fuel model may be the most appropriate choice for this fuel type.



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 17

Site Information

Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	103 trees/acre; basal area 95 feet/acre; stocking 69 percent
Overstory composition	Chestnut oak, red maple, northern red oak, white oak
Understory composition	Mountain laurel
Aspect/elevation/slope	South; 1,800 feet; 5 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

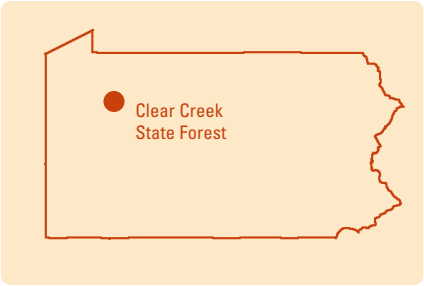
Fuel Characteristics

Leaf litter	3.4 tons/acre	Litter cover	100 percent
1-hour woody	4.1 tons/acre	Shrub cover	95 percent
10-hour woody	4.5 tons/acre	Ave. fuel height	3.3 feet
100-hour woody	6.6 tons/acre	Ave. fuel moisture	15 percent
1,000-hour woody	8.2 tons/acre	Optimal fuel model	5*
Total fuels	26.8 tons/acre	Min/max fuel model	10*, 4*

Weather and Fire Behavior Data

Air temperature	64 °F	Burn date/time	01 May 2003, 1200
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	5 to 10 feet
Cloud cover	50 percent	Rates of spread	5 to 10 feet/minute
Days since rain, amt.	3, 0.25 inch		

* None of the 13 standard fuel models adequately characterize mountain laurel. Developing a custom fuel model may be the most appropriate choice for this fuel type.



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 18

Site Information

Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	103 trees/acre; basal area 95 feet/acre; stocking 69 percent
Overstory composition	Chestnut oak, red maple, northern red oak, white oak
Understory composition	Mountain laurel
Aspect/elevation/slope	South; 1,800 feet; 5 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

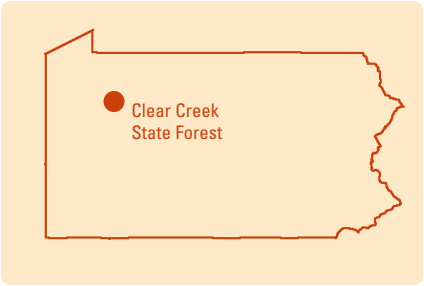
Fuel Characteristics

Leaf litter	3.6 tons/acre	Litter cover	100 percent
1-hour woody	4.4 tons/acre	Shrub cover	95 percent
10-hour woody	4.2 tons/acre	Ave. fuel height	4.0 feet
100-hour woody	6.9 tons/acre	Ave. fuel moisture	15 percent
1,000-hour woody	7.7 tons/acre	Optimal fuel model	5*
Total fuels	26.8 tons/acre	Min/max fuel model	10*, 4*

Weather and Fire Behavior Data

Air temperature	64 °F	Burn date/time	01 May 2003, 1200
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	5 to 10 feet
Cloud cover	50 percent	Rates of spread	5 to 10 feet/minute
Days since rain, amt.	3, 0.25 inch		

* None of the 13 standard fuel models adequately characterize mountain laurel. Developing a custom fuel model may be the most appropriate choice for this fuel type.



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 19

Site Information

Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	103 trees/acre; basal area 95 feet/acre; stocking 69 percent
Overstory composition	Chestnut oak, red maple, northern red oak, white oak
Understory composition	Mountain laurel
Aspect/elevation/slope	South; 1,800 feet; 5 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

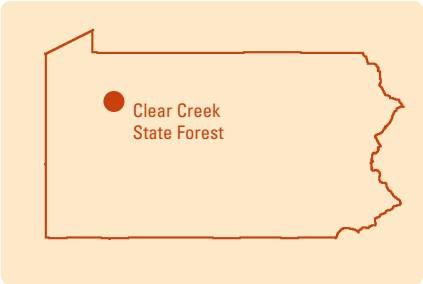
Fuel Characteristics

Leaf litter	3.7 tons/acre	Litter cover	100 percent
1-hour woody	4.2 tons/acre	Shrub cover	95 percent
10-hour woody	3.5 tons/acre	Ave. fuel height	4.0 feet
100-hour woody	8.1 tons/acre	Ave. fuel moisture	15 percent
1,000-hour woody	7.6 tons/acre	Optimal fuel model	5*
Total fuels	27.1 tons/acre	Min/max fuel model	10*, 4*

Weather and Fire Behavior Data

Air temperature	64 °F	Burn date/time	01 May 2003, 1200
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	5 to 10 feet
Cloud cover	50 percent	Rates of spread	5 to 10 feet/minute
Days since rain, amt.	3, 0.25 inch		

* None of the 13 standard fuel models adequately characterize mountain laurel. Developing a custom fuel model may be the most appropriate choice for this fuel type.



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Ericaceous Shrub 20

Site Information

Location	Clear Creek State Forest, Jefferson County, Pennsylvania
Overstory metrics	103 trees/acre; basal area 95 feet/acre; stocking 69 percent
Overstory composition	Chestnut oak, red maple, northern red oak, white oak
Understory composition	Mountain laurel
Aspect/elevation/slope	South; 1,800 feet; 2 percent
Stand history	Gypsy moth mortality and salvage harvest in late 1980s

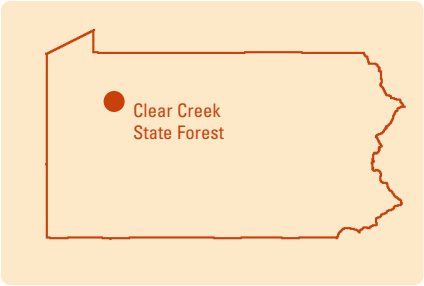
Fuel Characteristics

Leaf litter	3.6 tons/acre	Litter cover	100 percent
1-hour woody	4.8 tons/acre	Shrub cover	95 percent
10-hour woody	5.3 tons/acre	Ave. fuel height	4.5 feet
100-hour woody	5.1 tons/acre	Ave. fuel moisture	15 percent
1,000-hour woody	9.1 tons/acre	Optimal fuel model	5*
Total fuels	27.9 tons/acre	Min/max fuel model	10*, 4*

Weather and Fire Behavior Data

Air temperature	64 °F	Burn date/time	01 May 2003, 1200
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	South	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	8 to 15 feet
Cloud cover	50 percent	Rates of spread	5 to 10 feet/minute
Days since rain, amt.	3, 0.25 inch		

* None of the 13 standard fuel models adequately characterize mountain laurel. Developing a custom fuel model may be the most appropriate choice for this fuel type.



Photos by Patrick Brose, U.S. Forest Service

Logging Slash

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 1

Site Information

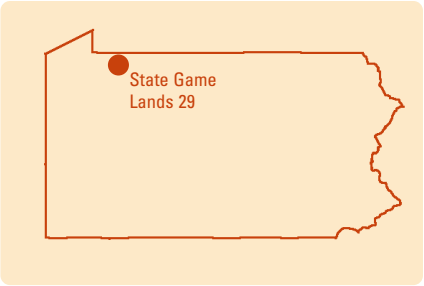
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

Leaf litter	3.0 tons/acre	Litter cover	100 percent
1-hour woody	0.9 tons/acre	Shrub cover	0 percent
10-hour woody	3.2 tons/acre	Ave. fuel height	0.8 feet
100-hour woody	3.7 tons/acre	Ave. fuel moisture	17 percent
1,000-hour woody	1.5 tons/acre	Optimal fuel model	6 or 10
Total fuels	12.3 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air Temperature	72 °F	Burn date/time	19 Apr 2006, 1100
Relative humidity	27 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 2 feet
Cloud cover	0 percent	Rates of spread	1 to 5 feet/minute
Days since rain, amt.	4, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 2

Site Information

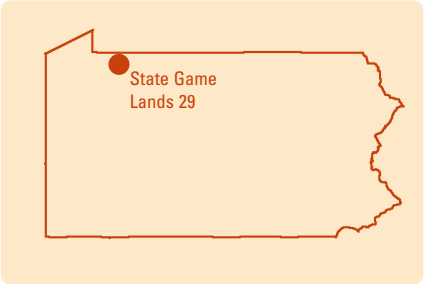
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

Leaf litter	2.6 tons/acre	Litter cover	100 percent
1-hour woody	1.0 tons/acre	Shrub cover	0 percent
10-hour woody	3.5 tons/acre	Ave. fuel height	1.5 feet
100-hour woody	3.8 tons/acre	Ave. fuel moisture	18 percent
1,000-hour woody	3.6 tons/acre	Optimal fuel model	6 or 10
Total fuels	14.5 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	72 °F	Burn date/time	19 Apr 2006, 1100
Relative humidity	27 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 3 feet
Cloud cover	0 percent	Rates of spread	1 to 6 feet/minute
Days since rain, amt.	4, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 3

Site Information

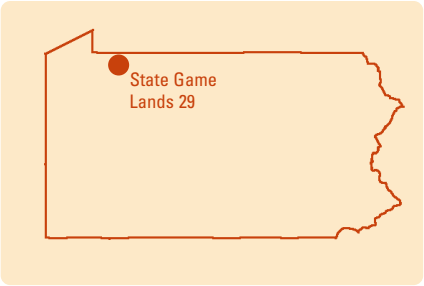
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

Leaf litter	3.1 tons/acre	Litter cover	100 percent
1-hour woody	1.4 tons/acre	Shrub cover	0 percent
10-hour woody	4.6 tons/acre	Ave. fuel height	1.2 feet
100-hour woody	3.5 tons/acre	Ave. fuel moisture	18 percent
1,000-hour woody	3.7 tons/acre	Optimal fuel model	6 or 10
Total fuels	16.3 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	72 °F	Burn date/time	19 Apr 2006, 1100
Relative humidity	27 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 3 feet
Cloud cover	0 percent	Rates of spread	1 to 5 feet/minute
Days since rain, amt.	4, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 4

Site Information

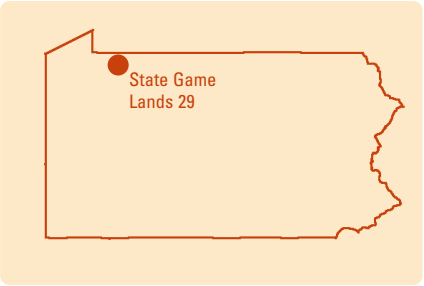
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, Northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

Leaf litter	3.1 tons/acre	Litter cover	100 percent
1-hour woody	1.4 tons/acre	Shrub cover	0 percent
10-hour woody	2.6 tons/acre	Ave. fuel height	1.5 feet
100-hour woody	6.5 tons/acre	Ave. fuel moisture	18 percent
1,000-hour woody	4.7 tons/acre	Optimal fuel model	6 or 10
Total fuels	18.3 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	72 °F	Burn date/time	19 Apr 2006, 1100
Relative humidity	27 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 3 feet
Cloud cover	0 percent	Rates of spread	2 to 6 feet/minute
Days since rain, amt.	4, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 5

Site Information

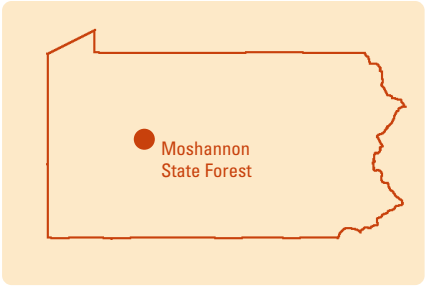
Location	Moshannon State Forest, Clearfield County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 2,300 feet; 2 percent
Stand history	Shelterwood first removal cut in 2001

Fuel Characteristics

Leaf litter	3.0 tons/acre	Litter cover	100 percent
1-hour woody	1.6 tons/acre	Shrub cover	20 percent
10-hour woody	3.5 tons/acre	Ave. fuel height	1.2 feet
100-hour woody	5.5 tons/acre	Ave. fuel moisture	17 percent
1,000-hour woody	5.1 tons/acre	Optimal fuel model	6 or 10
Total fuels	18.7 tons/acre	Min/Max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	70 °F	Burn date/time	04 May 2004, 1300
Relative humidity	30 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	1 to 3 feet
Cloud cover	0 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	4, 0.2		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 6

Site Information

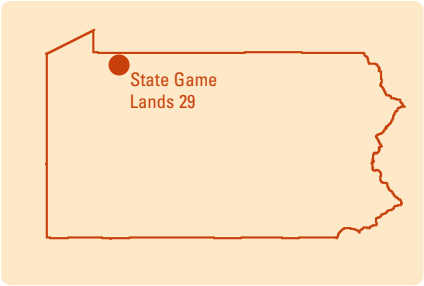
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

Leaf litter	2.7 tons/acre	Litter cover	100 percent
1-hour woody	0.8 tons/acre	Shrub cover	0 percent
10-hour woody	2.4 tons/acre	Ave. fuel height	1.5 feet
100-hour woody	7.1 tons/acre	Ave. fuel moisture	18 percent
1,000-hour woody	6.3 tons/acre	Optimal fuel model	6 or 10
Total fuels	19.3 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	72 °F	Burn date/time	19 Apr 2006, 1100
Relative humidity	27 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 4 feet
Cloud cover	0 percent	Rates of spread	3 to 7 feet/minute
Days since rain, amt.	4, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 7

Site Information

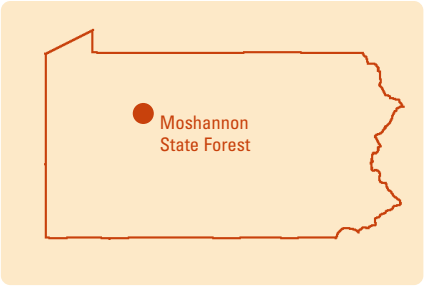
Location	Moshannon State Forest, Clearfield County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 2,300 feet; 2 percent
Stand history	Shelterwood first removal cut in 2001

Fuel Characteristics

Leaf litter	3.0 tons/acre	Litter cover	100 percent
1-hour woody	1.2 tons/acre	Shrub cover	20 percent
10-hour woody	2.5 tons/acre	Ave. fuel height	1.2 feet
100-hour woody	5.4 tons/acre	Ave. fuel moisture	17 percent
1,000-hour woody	8.1 tons/acre	Optimal fuel model	6 or 10
Total fuels	20.2 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	70 °F	Burn date/Time	04 May 2004, 1300
Relative humidity	30 percent	Firing device	Drip torch
Wind Direction	West	Firing pattern	Strip-head fire
Wind Speed	1 to 3 miles/hour	Flame lengths	1 to 3 feet
Cloud Cover	0 percent	Rates of spread	2 to 5 feet/minute
Days since rain, amt.	4, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 8

Site Information

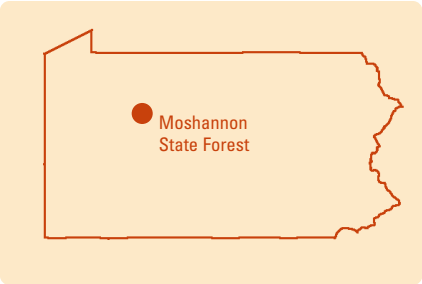
Location	Moshannon State Forest, Clearfield County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 2,300 feet; 2 percent
Stand history	Shelterwood first removal cut in 2003

Fuel Characteristics

Leaf litter	2.4 tons/acre	Litter cover	100 percent
1-hour woody	1.3 tons/acre	Shrub cover	20 percent
10-hour woody	2.8 tons/acre	Ave. fuel height	1.8 feet
100-hour woody	5.0 tons/acre	Ave. fuel moisture	11 percent
1,000-hour woody	11.3 tons/acre	Optimal fuel model	6 or 10
Total fuels	22.8 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	73 °F	Burn date/time	06 May 2008, 1400
Relative humidity	26 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 4 feet
Cloud cover	0 percent	Rates of spread	3 to 7 feet/minute
Days since rain, amt.	4, 0.2		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 9

Site Information

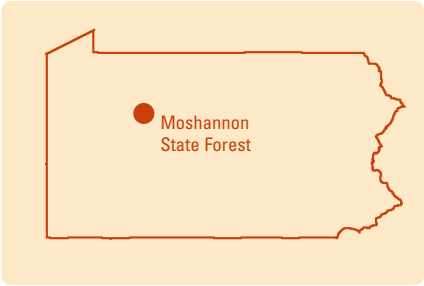
Location	Moshannon State Forest, Clearfield County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 2,300 feet; 2 percent
Stand history	Shelterwood first removal cut in 2003

Fuel Characteristics

Leaf litter	3.0 tons/acre	Litter cover	100 percent
1-hour woody	1.4 tons/acre	Shrub cover	20 percent
10-hour woody	2.1 tons/acre	Ave. fuel height	1.6 feet
100-hour woody	6.2 tons/acre	Ave. fuel moisture	12 percent
1,000-hour woody	12.5 tons/acre	Optimal fuel model	6 or 10
Total fuels	25.2 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	70 °F	Burn date/time	06 May 2008, 1100
Relative humidity	30 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 4 feet
Cloud cover	0 percent	Rates of spread	3 to 7 feet/minute
Days since rain, amt.	4, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 10

Site Information

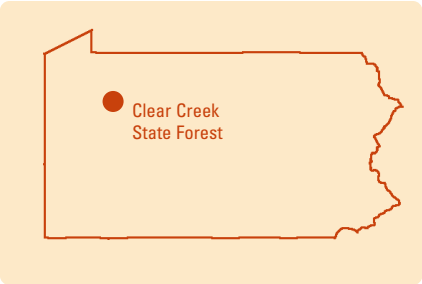
Location	Clear Creek State Forest, Venango County, Pennsylvania
Overstory metrics	75 trees/acre; basal area 83 feet/acre; stocking 68 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Northern red oak, black birch, red maple, mixed fern
Aspect/elevation/slope	Southeast; 1,650 feet; 12 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

Leaf litter	2.8 tons/acre	Litter cover	100 percent
1-hour woody	2.0 tons/acre	Shrub cover	0 percent
10-hour woody	4.7 tons/acre	Ave. fuel height	2.2 feet
100-hour woody	7.8 tons/acre	Ave. fuel moisture	10 percent
1,000-hour woody	10.5 tons/acre	Optimal fuel model	6 or 10
Total fuels	27.8 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	77 °F	Burn date/time	07 May 2007, 1100
Relative humidity	35 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 6 feet
Cloud cover	0 percent	Rates of spread	3 to 8 feet/minute
Days since rain, amt.	5, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 11

Site Information

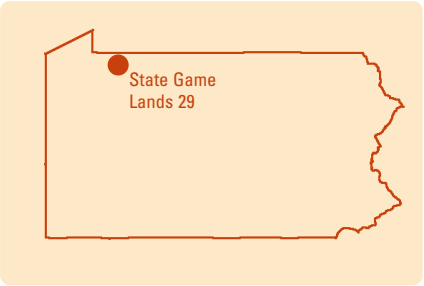
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	21 trees/acre; basal area 11 feet/acre; stocking 15 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Pin cherry, black birch, red maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 1996, final harvest in 2001

Fuel Characteristics

Leaf litter	2.6 tons/acre	Litter cover	90 percent
1-hour woody	0.3 tons/acre	Shrub cover	0 percent
10-hour woody	1.2 tons/acre	Ave. fuel height	1.3 feet
100-hour woody	5.6 tons/acre	Ave. fuel moisture	9 percent
1,000-hour woody	18.5 tons/acre	Optimal fuel model	12
Total fuels	28.2 tons/acre	Min/max fuel model	10, 13

Weather and Fire Behavior Data

Air temperature	68 °F	Burn date/time	03 May 2006, 1000
Relative humidity	34 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	2 to 3 miles/hour	Flame lengths	3 to 8 feet
Cloud cover	0 percent	Rates of spread	3 to 7 feet/minute
Days since rain, amt.	6, 0.25 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 12

Site Information

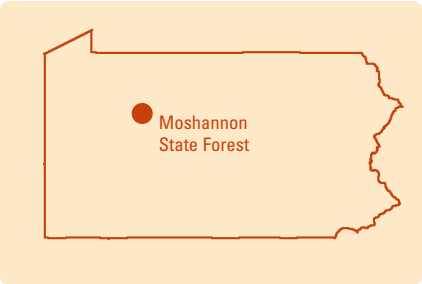
Location	Moshannon State Forest, Clearfield County, Pennsylvania
Overstory metrics	148 trees/acre; basal area 115 feet/acre; stocking 84 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Black birch, red maple, striped maple, northern red oak
Aspect/elevation/slope	South; 2,300 feet; 2 percent
Stand history	Shelterwood first removal cut in 2003

Fuel Characteristics

Leaf litter	3.5 tons/acre	Litter cover	100 percent
1-hour woody	1.5 tons/acre	Shrub cover	10 percent
10-hour woody	2.8 tons/acre	Ave. fuel height	1.8 feet
100-hour woody	7.7 tons/acre	Ave. fuel moisture	12 percent
1,000-hour woody	14.1 tons/acre	Optimal fuel model	6 or 10
Total fuels	29.6 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	73 °F	Burn date/time	06 May 2008, 1430
Relative humidity	26 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 4 feet
Cloud cover	0 percent	Rates of spread	3 to 7 feet/minute
Days since rain, amt.	4, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 13

Site Information

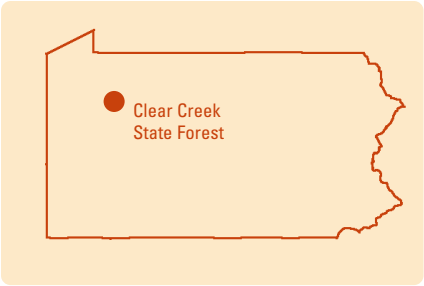
Location	Clear Creek State Forest, Venango County, Pennsylvania
Overstory metrics	75 trees/acre; basal area 83 feet/acre; stocking 68 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Northern red oak, black birch, red maple, mixed fern
Aspect/elevation/slope	Southeast; 1,650 feet; 17 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

Leaf litter	2.7 tons/acre	Litter cover	100 percent
1-hour woody	2.3 tons/acre	Shrub cover	0 percent
10-hour woody	4.4 tons/acre	Ave. fuel height	2.0 feet
100-hour woody	6.8 tons/acre	Ave. fuel moisture	10 percent
1,000-hour woody	13.9 tons/acre	Optimal fuel model	6 or 10
Total fuels	30.1 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	77 °F	Burn date/time	07 May 2007, 1100
Relative humidity	35 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 6 feet
Cloud cover	0 percent	Rates of spread	3 to 8 feet/minute
Days since rain, amt.	5, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 14

Site Information

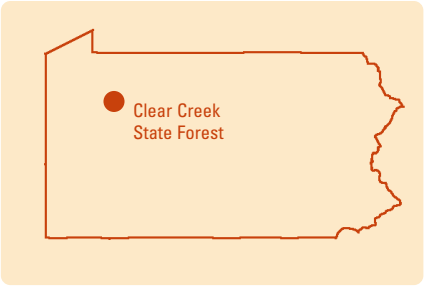
Location	Clear Creek State Forest, Venango County, Pennsylvania
Overstory metrics	75 trees/acre; basal area 83 feet/acre; stocking 68 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Northern red oak, black birch, red maple, mixed fern
Aspect/elevation/slope	Southeast; 1,650 feet; 17 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

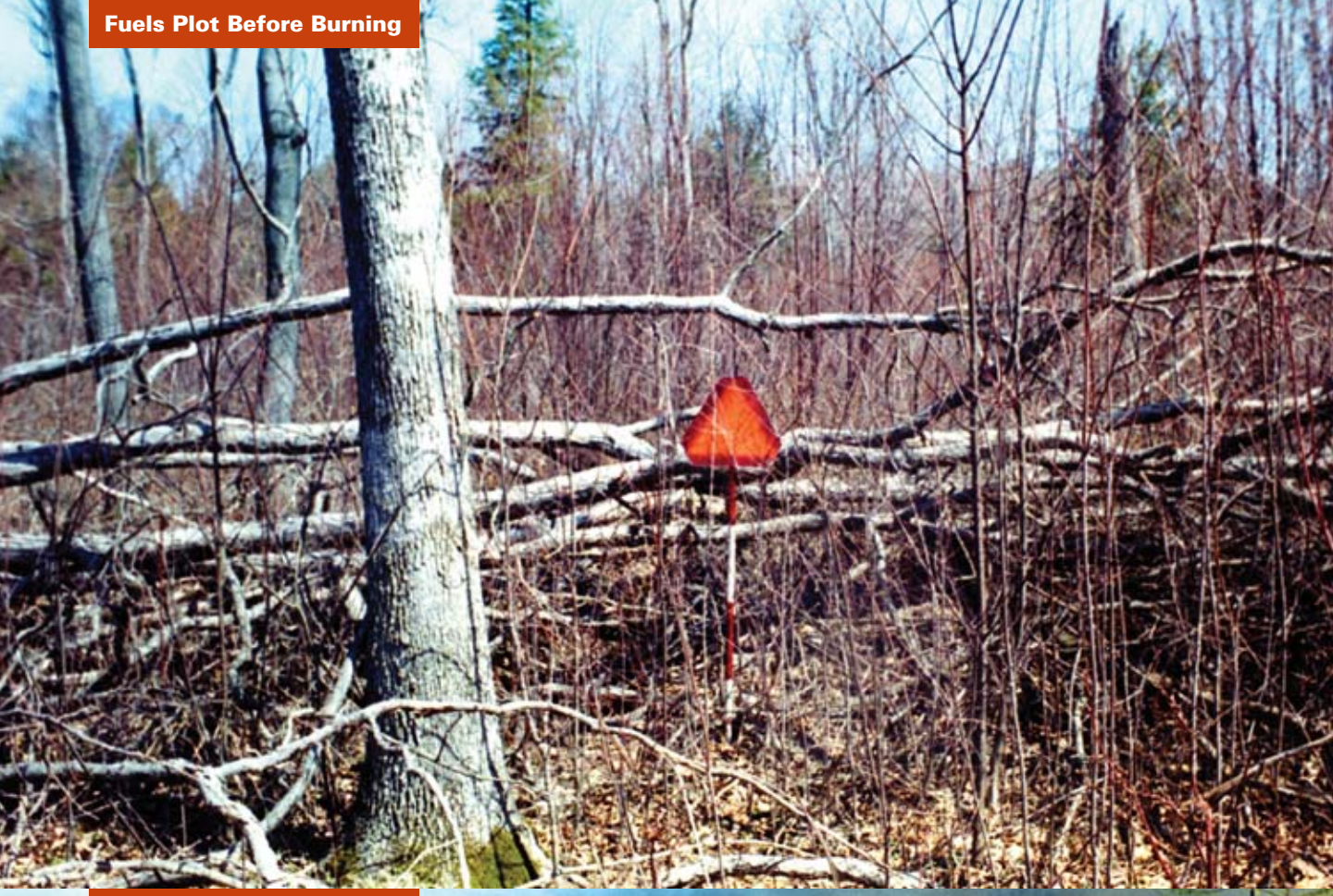
Leaf litter	3.2 tons/acre	Litter cover	100 percent
1-hour woody	2.4 tons/acre	Shrub cover	0 percent
10-hour woody	4.1 tons/acre	Ave. fuel height	2.5 feet
100-hour woody	7.0 tons/acre	Ave. fuel moisture	10 percent
1,000-hour woody	14.0 tons/acre	Optimal fuel model	6 or 10
Total fuels	30.7 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	77 °F	Burn date/time	07 May 2007, 1100
Relative humidity	35 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 6 feet
Cloud cover	0 percent	Rates of spread	3 to 8 feet/minute
Days since rain, amt.	5, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service



Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 15

Site Information

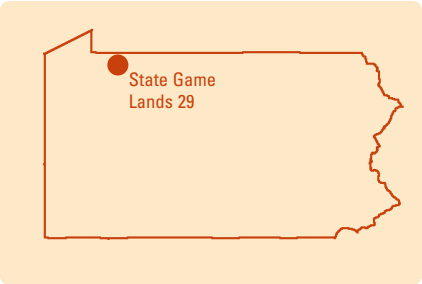
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	21 trees/acre; basal area 11 feet/acre; stocking 15 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Pin cherry, black birch, red maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 1996, final harvest in 2001

Fuel Characteristics

Leaf litter	3.0 tons/acre	Litter cover	90 percent
1-hour woody	0.4 tons/acre	Shrub cover	0 percent
10-hour woody	1.5 tons/acre	Ave. fuel height	1.3 feet
100-hour woody	7.8 tons/acre	Ave. fuel moisture	9 percent
1,000-hour woody	18.7 tons/acre	Optimal fuel model	12
Total fuels	31.4 tons/acre	Min/max fuel model	10, 13

Weather and Fire Behavior Data

Air temperature	66 °F	Burn date/time	03 May 2006, 0930
Relative humidity	33 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 2 miles/hour	Flame lengths	2 to 6 feet
Cloud cover	0 percent	Rates of spread	3 to 8 feet/minute
Days since rain, amt.	6, 0.25 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 16

Site Information

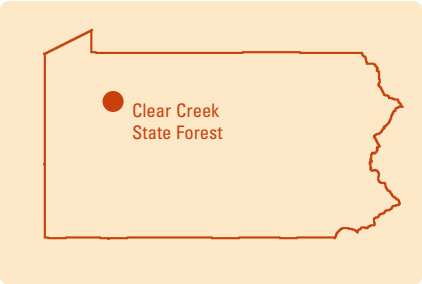
Location	Clear Creek State Forest, Venango County, Pennsylvania
Overstory metrics	112 trees/acre; basal area 91 feet/acre; stocking 73 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Northern red oak, black birch, red maple, mixed fern
Aspect/elevation/slope	Northwest; 1,650 feet; 3 percent
Stand history	Shelterwood first removal cut in 2002

Fuel Characteristics

Leaf litter	3.2 tons/acre	Litter cover	100 percent
1-hour woody	2.1 tons/acre	Shrub cover	0 percent
10-hour woody	4.2 tons/acre	Ave. fuel height	3.0 feet
100-hour woody	7.5 tons/acre	Ave. fuel moisture	10 percent
1,000-hour woody	14.8 tons/acre	Optimal fuel model	6 or 10
Total fuels	31.8 tons/acre	Min/max fuel model	9, 12

Weather and Fire Behavior Data

Air temperature	77 °F	Burn date/time	07 May 2007, 1100
Relative humidity	35 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	1 to 3 miles/hour	Flame lengths	2 to 6 feet
Cloud cover	0 percent	Rates of spread	3 to 8 feet/minute
Days since rain, amt.	5, 0.2 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 17

Site Information

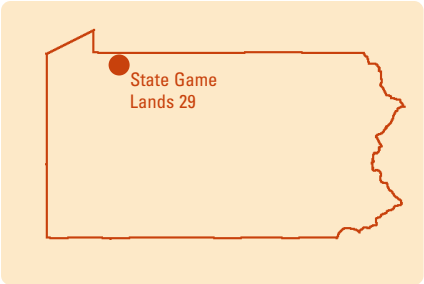
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	21 trees/acre; basal area 11 feet/acre; stocking 15 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Pin cherry, black birch, red maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 1996, final harvest in 2001

Fuel Characteristics

Leaf litter	3.0 tons/acre	Litter cover	90 percent
1-hour woody	0.3 tons/acre	Shrub cover	0 percent
10-hour woody	1.4 tons/acre	Ave. fuel height	2.3 feet
100-hour woody	9.6 tons/acre	Ave. fuel moisture	9 percent
1,000-hour woody	18.9 tons/acre	Optimal fuel model	12
Total fuels	33.2 tons/acre	Min/max fuel model	10, 13

Weather and Fire Behavior Data

Air temperature	75 °F	Burn date/time	03 May 2006, 1430
Relative humidity	25 percent	Firing device	Drip torch
Wind direction	Northwest	Firing pattern	Strip-head fire
Wind speed	4 to 6 miles/hour	Flame lengths	4 to 8 feet
Cloud cover	0 percent	Rates of spread	5 to 9 feet/minute
Days since rain, amt.	6, 0.25 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 18

Site Information

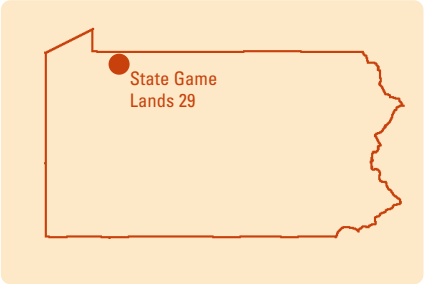
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	21 trees/acre; basal area 11 feet/acre; stocking 15 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Pin cherry, black birch, red maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 1996, final harvest in 2001

Fuel Characteristics

Leaf litter	2.9 tons/acre	Litter cover	90 percent
1-hour woody	0.3 tons/acre	Shrub cover	0 percent
10-hour woody	1.8 tons/acre	Ave. fuel height	3.3 feet
100-hour woody	9.8 tons/acre	Ave. fuel moisture	9 percent
1,000-hour woody	20.0 tons/acre	Optimal fuel model	12
Total fuels	34.8 tons/acre	Min/max fuel model	10, 13

Weather and Fire Behavior Data

Air temperature	70 °F	Burn date/time	03 May 2006, 1130
Relative humidity	29 percent	Firing device	Drip torch
Wind direction	Northwest	Firing pattern	Strip-head fire
Wind speed	2 to 3 miles/hour	Flame lengths	5 to 10 feet
Cloud cover	10 percent	Rates of spread	4 to 9 feet/minute
Days since rain, amt.	6, 0.25 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 19

Site Information

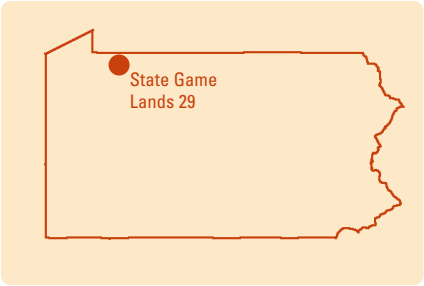
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	21 trees/acre; basal area 11 feet/acre; stocking 15 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Pin cherry, black birch, red maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 1996, final harvest in 2001

Fuel Characteristics

Leaf litter	2.2 tons/acre	Litter cover	90 percent
1-hour woody	0.1 tons/acre	Shrub cover	0 percent
10-hour woody	1.2 tons/acre	Ave. fuel height	3.3 feet
100-hour woody	8.5 tons/acre	Ave. fuel moisture	9 percent
1,000-hour woody	27.1 tons/acre	Optimal fuel model	12
Total fuels	39.1 tons/acre	Min/max fuel model	10, 13

Weather and Fire Behavior Data

Air temperature	77 °F	Burn date/time	03 May 2006, 1500
Relative humidity	24 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	2 to 4 miles/hour	Flame lengths	5 to 15 feet
Cloud cover	0 percent	Rates of spread	4 to 8 feet/minute
Days since rain, amt.	6, 0.25 inch		



Photos by Patrick Brose, U.S. Forest Service

Fuels Plot Before Burning

Fuels Plot Fire Behavior

Logging Slash 20

Site Information

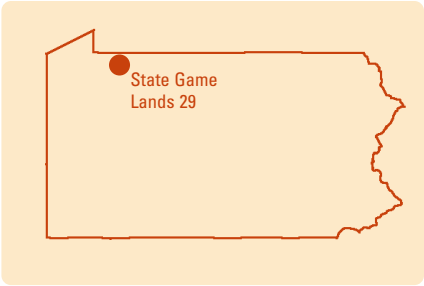
Location	State Game Lands 29, Warren County, Pennsylvania
Overstory metrics	21 trees/acre; basal area 11 feet/acre; stocking 15 percent
Overstory composition	Northern red oak, red maple, black cherry, white oak
Understory composition	Pin cherry, black birch, red maple, northern red oak
Aspect/elevation/slope	South; 1,900 feet; 2 percent
Stand history	Shelterwood first removal cut in 1996, final harvest in 2001

Fuel Characteristics

Leaf litter	2.8 tons/acre	Litter cover	90 percent
1-hour woody	0.5 tons/acre	Shrub cover	0 percent
10-hour woody	1.9 tons/acre	Ave. fuel height	2.8 feet
100-hour woody	12.9 tons/acre	Ave. fuel moisture	9 percent
1,000-hour woody	23.2 tons/acre	Optimal fuel model	12
Total fuels	41.3 tons/acre	Min/max fuel model	10, 13

Weather and Fire Behavior Data

Air temperature	73 °F	Burn date/time	03 May 2006, 1000
Relative humidity	24 percent	Firing device	Drip torch
Wind direction	West	Firing pattern	Strip-head fire
Wind speed	2 to 3 miles/hour	Flame lengths	4 to 8 feet
Cloud cover	0 percent	Rates of spread	3 to 9 feet/minute
Days since rain, amt.	6, 0.25 inch		



Photos by Patrick Brose, U.S. Forest Service

Brose, Patrick H. 2009. **Photo guide for estimating fuel loading and fire behavior in oak forests of the mid-Atlantic region.** Gen. Tech. Rep. NRS-45. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 104 p.

A field guide of 45 pairs of photographs depicting ericaceous shrub, leaf litter, and logging slash fuel types of eastern oak forests and observed fire behavior of these fuel types during prescribed burning. The guide contains instructions on how to use the photo guide to choose appropriate fuel models for prescribed fire planning.

KEY WORDS: ericaceous shrubs, leaf litter, logging slash, prescribed fire, *Quercus*

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